Journal of Aircraft and Spacecraft Technology

Original Research Paper

Presentation of the New Invention of an Emergency System that Saves an Airplane after an Accident or Failure with a Navigation Application of the New Invention about Rotating Objects

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Article history
Received: 28-03-2024
Revised: 20-04-2024
Accepted: 10-05-2024

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Abstract: Airplanes are nowadays the main transport solution for travelers and this makes aviation one of the most important and strategic social and economic fields. However, tragedies of airplane incidents can happen because of human or technical faults or even bad weather which threatens this field. Furthermore, these aviation incidents are very deadly and the current aviation safety measures and technologies are not enough in order to completely succeed in the rescue of travelers, pilots and cargo of an airplane in free fall in the air. Many inventions are proposed as solutions for the safety of these airplanes but their application is difficult and requires the rebalancing of the aircraft in free fall which is a hard task. This study aims to present a summary of the new invention in aviation which was accepted in the Moroccan Office of Industrial and Commercial Property (OMPIC) in Morocco. This invention enables the rescue in air in case of an accident or failure in an airplane. Current technological advances in fuel propulsion power and material strength make this invention summarized here possible to save hundreds of lives every year. This article explains also a new proposed navigation system based on a second invention filed in the same Moroccan Office of Patents which can be very useful for aircraft and even other vessels like submarines. This navigation system based on principles of the compass is a very cheap computerized analysis and control system which, compared to other declared benchmarks, can make airplanes achieve navigation more independent from terrestrial control stations and satellites and can significantly enhance future autopilot systems. The students and even the experts are therefore invited to understand both these two inventions since the presented methods can be used even in other inventions in different fields regarding moving objects. The specialists in aviation will also find in this article a new opportunity to enhance the safety measures and technologies of this important field of transport.

Keywords: Aircraft, Airplane, Aerospace, Aviation, Navigation, Method, Compass, Inclinometer, Reference Frame, Rotations, Thruster, Computerized System, Moving Objects, Geoscience, Invention, Patent

Introduction

Navigation is a scientific and technical field that humans have developed in order to improve the control of their vessels and machines in the air or in the water (López-Lago *et al*., 2020). Navigation techniques go beyond what is theoretical and currently rely on the precision and speed of computer calculations (Chandu *et al*., 2007). As a result, we find several works and inventions that aim to improve navigation systems in order to make our machines more secure and more efficient in the air or in the water (Groves, 2015). Most of the recent patents of the invention which are related to the subject of this article deal mainly with airplane propulsion issues like thrusters of translation (Giroux *et al*., 2021). Furthermore, recent inventors usually neglect to develop the known theoretical principles of airplane system of control and that is what makes the content of this article more interesting.

DOI: 10.3844/jastsp.2024.4.13

This article aims to present the new invention accepted in the Moroccan Office of Industrial and Commercial Property (OMPIC) in the field of airplane safety (Louiz, 2023a) and also to explain a new experimental procedure that uses principles of compasses that is used in this invention. This method of navigation is based on the second invention regarding the study of the rotations of moving objects (Louiz, 2023b) which was filed in Morocco and is very useful for the navigation of aircraft in the air or other moving vessels like submarines in the water.

Tragic airplane incidents are caused by human or technical faults or even bad weather. However, airplane incidents are very deadly since the speed and momentum of a free-falling airplane are very great in comparison to the strength of the airplane's materials or established aviation safety measures.

Generally, when an airplane in the air has an accident or breaks down, the airplane falls into free fall but its movements during this free fall must be well controlled otherwise the deployment of the aerostat will not work and will be useless. We know that other solutions are proposed for the safety of airplanes but the realization of the majority of them requires the rebalancing of the airplane in free fall. In this article, we will then summarize the description of this invention entitled in French “un système d’urgence en cas d’accident ou de défaillance dans un avion pour permettre le sauvetage” (Louiz, 2023a). Then we will present the new navigation technique applied in this invention and which takes advantage of the principles of the compass and inclinometers based on the second invention about the study of rotating objects entitled in French “un système informatisé qui utilise le champ électromagnétique de la terre pour détecter les rotations d'un objet de façon autonome avec seulement un repère fixe à cet objet” (Louiz, 2023b).

Many other works tried previously to study theoretically and experimentally the rotations of moving objects by applying geometry methods (Morawiec, 2004) and by the use of the classical laws of Newtonian Mechanics, (Usubamatov, 2022) and many other techniques and methods have been proposed to detect these rotations by using rotation-equivariant (Han *et al*., 2021) or by using remote sensing (Li *et al*., 2018). However, all these works use external reference frames or external sensing procedures and they are very similar to a known expired invention of the inventor Reister Russell patented in the USA in 1969 (Reister, 1969). External sensing is useless in the inventions of this article about rotating objects (Louiz, 2023b) and this is the fact that makes this applied invention of objects very useful in many different application fields and not only in the navigation explained in this article. Furthermore, the mathematical tools used in this article are very simple thanks to the use of principles of the compass compared to the other research articles which apply methods based on the change of references and may apply other tools of pure mathematics and matrices (Hall and Sands, 2023) whereas the efficiency of these pure mathematics methods of kinematic rotations especially with high linear speed of rotation generally in physics has been criticized in the beginning of a new research about the use of pure mathematics with Newtonian mechanics in Astronomy (satellites) and quantum mechanics (Louiz, 2020).

A previous South Korean invention (Lim *et al*., 2013) patented in 2013 uses principles of the electromagnetic field of Earth and ideas similar to the ones presented in this article. However, the South Korean invention uses only one inclinometer and different mathematical models based on matrices in order to find solutions. Hence, only the specialists in the industrial fields of application will prove the usefulness and the real abilities of each invention.

Summary of the New Emergency System Invention that Enables Rescue in the Event of an Accident or Failure in an Airplane

The invention summarized in this article is entitled in French "un système d'urgence en cas d'accident ou de défaillance dans un avion pour permettre le sauvetage". It is an emergency system that uses thrusters to restore balance in the air to a broken down or damaged airplane, which allows safe and reliable deployment of the emergency aerostat. This thruster system uses computer data from a control system to bring the airplane back into balance and even help it navigate with the aerostat and this allows the rescue of travelers, pilots and cargo.

The thruster system of this invention is divided into four components:

- A computerized analysis and control system (computer + computer program) that uses principles of compass angles and inclinometers in order to use the thrusters in a rational and useful manner
- At least 18 main thrusters: 6 translation thrusters and 12 rotation thrusters (Fig. 1)
- At least 18 secondary thrusters: 6 translation thrusters and 12 rotation thrusters (Fig. 1)
- A system of adjustment of the G point which is the center of gravity of the airplane

Figure 1 shows, along the axes (vectors "i", "j" and "k"), the point G of the airplane and shows at the view from below the airplane the positions of the main rotation thrusters at the circled locations 1 and 3 and at the circled locations I and III. These four thrusters have a direction of propulsion towards the bottom of the airplane when it flies parallel to the geometric plane of the sea level and can also participate in altitude control. We can guess the thruster's positions 2 and 4 and II and IV by symmetry in the view from over the airplane. There are also secondary thrusters at the circled locations A and C which have a downward propulsion direction too. We can also guess B and D by symmetry in the view from over the airplane. All these thrusters collaborate in order to perform rotations for the airplane around axes "i" and "j".

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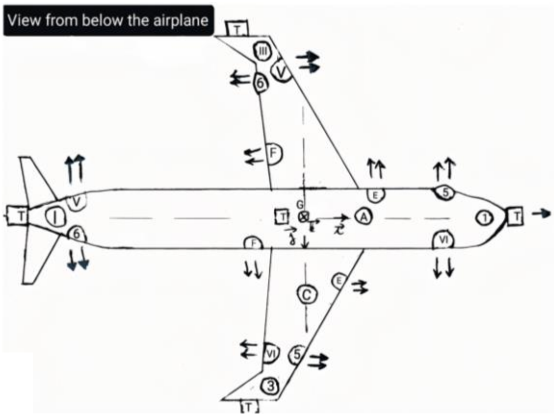

Fig. 1: The location of the thrusters and the orthonormal reference frame of the compass principle in the view from below the airplane

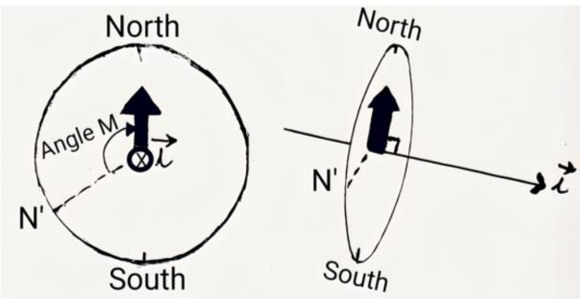

Fig. 2: The location of the axis "i" in the center of the magnetic compass with the perpendicularity of this axis to the compass disk

Figure 1 also shows the propulsion orientations and possible locations of four other main thrusters at the dual circled locations 5 and 6 and the dual circled locations V and VI. There are also two secondary thrusters in the dual circled locations E and F. These locations are all located on the sides of the airplane (neither the top nor the bottom of the airplane) in order to perform a rotation of the airplane around the axis "k" and can also collaborate in propelling the airplane forward or backward. The thrusters named "T" in squares are used for the translations of the airplane.

Figure 2 shows the exact location of axis "i" which is one of the three axes defined in this description for the airplane. Using the principle of compasses requires that this axis must pass exactly through the center of the compass and it must be exactly perpendicular to the compass disk in order to have the best precision. The angle M between the needle and the radius of point N' informs about the angle of rotation of the airplane around the axis "i" between two consecutive moments.

Short Explanations

The main thrusters are placed relatively far from the center of gravity of the airplane to take advantage of a large rotational moment because at least 12 main thrusters control the rotational movements of the airplane and at least 6 main thrusters control the movements of translation of the airplane forward or backward, to the left or right (starboard and port) and up or down (altitude) and these 6 thrusters are also useful for navigation of the airplane after the deployment of the aerostat. Another patent of invention is related to the patent of invention that is presented in this article deals mainly with the airplane thrusters of translation and their system of control (Giroux *et al*., 2021).

In the event of an airplane accident in the air, one or more parts of the airplane, especially at the ends, are often damaged by the accident. In this case, secondary thrusters which are placed in safer locations in the airplane should fire to replace the main thrusters.

The computerized system that controls the thrusters includes a detector that instantly detects the rotational and translational movements of the airplane and then transmits this movement information to a computer that chooses the best approach to rebalance the airplane back. Then, the thrusters are controlled by this computerized system to perform this rebalancing process in a very short time by abolishing the unwanted rotations caused by the accident or the failure of the airplane in the air.

To explain the method of this invention, it is enough to fix an orthonormal reference frame in the moving airplane, considering that the center of this reference frame is the center of gravity G of the airplane shown in Fig. 1. This orthonormal reference frame abolishes the study of the translations of the airplane which are easily detectable by other solutions. However, the airplane continues to rotate around the three axes of our orthonormal reference frame. We then place a rotation sensor on each of the axes of our frame since the rotation around each axis constitutes a degree of freedom. In this method. This sensor is connected to a compass because we will use in this study the principles of rotations of magnetic compasses.

In this invention, magnetic compasses and their sensors can be replaced by electronic or nuclear compasses. However, in this case, the electronic or nuclear compasses must be fixed in the airplane concerned by this invention in such a way that each electronic or nuclear compass plays exactly the same role as an equivalent magnetic compass. This means that, since each electronic or nuclear compass is equivalent in its work to an imaginary magnetic compass, it is necessary to define an imaginary disk of rotation of an imaginary needle for each electronic or nuclear compass and then place this electronic or nuclear compass on its corresponding axis of the orthonormal reference so that this axis must pass exactly through the center of the imaginary rotation disk of the imaginary needle of this electronic or nuclear compass and this axis must be exactly perpendicular to this rotation imaginary disk.

DOI: 10.3844/jastsp.2024.4.13

The airplane has three axes of rotation and six rotations on the fixed orthonormal reference frame. To study these six rotations, we need at least one compass for each axis. The system then needs at least three compasses attached to the airplane so that each of the three axes of the airplane passes perpendicular to the disk of each compass through the center of this compass. Each axis of rotation of the airplane then becomes the axis of rotation of each needle of the three compasses. Figure 2 gives an example of the location of the axis "i" in the middle of a compass. The other compasses are placed in the same way on the axes "j" and "k". The axes "i", "j" and "k" intersect at a single point G which is the center of gravity of the airplane shown in Fig. 1. The axes “i”, “j” and “k” intersect at the point G around which take place the rotations of the airplane and which must be studied by compasses.

The needle of each compass must then be connected to a sensor that continuously detects the angle of rotation of the needle, the angular speed of the needle and the angular acceleration of the needle.

The needle of each compass rotates without friction during its rotation to instantly indicate an angle of the ellipse of rotation in each compass which is the angle M shown in Fig. 2 between the directions of the magnetic north pole of the earth in two successive moments (N and N'). The rotation is considered elliptical in compasses because of the changing inclinations of these compasses relative to the geometric plane of the sea level. The computerized system of this invention includes therefore at least three inclinometers. Each inclinometer is fixed on one of the three axes of the orthonormal reference frame in a manner that makes it possible to continuously detect the inclination of each axis of the orthonormal reference frame relative to the plane of sea level. This means that each inclinometer is fixed in the object so that the inclination plane tested by this inclinometer is parallel to its corresponding axis. If the inclinometer is not electronic or nuclear, it must be equipped with the necessary sensors to make it at least equivalent to an electronic inclinometer.

This rotation study provides information on the true circular rotation of the airplane around each of its three axes. Thanks to the sensors, the computer analyzes the angles detected by the compass system and the inclinometers to know if the airplane control situation becomes critical in order to trigger the rescue thrusters if necessary. The priority of the computerized analysis and control system is obviously to keep the airplane stable at a high enough altitude to allow the use of a complementary rescue solution such as aerostats.

The use of these principles of compasses for the study of rotations requires that the point G which is the center of gravity of the airplane be fixed for an accurate study of rotations. There is obviously a regular change in the weight of an airplane's cargo, fuel and passengers, which causes the location of the airplane's G-point to vary. To remedy this problem, the airplane must then be equipped with a system that returns the G point to the correct position despite the variation caused by cargo and fuel consumption. Indeed, if this variation in the location of point G is small, then the location for fixing the compasses must be mobile to be able to constantly adjust inside the airplane automatically. However, if the variation in the location of the G point is big, the airplane must be equipped with a movable weight displacement system that changes the weight distributions in the airplane in order to abolish the large change in the location of point G in the airplane.

Explanations about the Navigation with the Principle of Compasses Used in this Invention

The purpose of this part of the article is to answer questions regarding the description of the compass principles that are used in this invention about airplane safety. We will use the content of the second invention about rotation objects (Louiz, 2023b) in order to prove the capacity and power of the new proposed system of navigation which is based on the principle of compasses and can be applied in the navigation of aircraft or other moving vessels like submarines.

This part of the article is therefore an application to airplane navigation and will be also of service to the programmers of the computerized system of this invention of airplane safety.

The Usual Case of the Airplane

If the compass system proposed in this invention consists of only three compasses where each compass is perpendicular to one of the three axes defined for the airplane in the description, then two compasses are perpendicular to the surface of the wings of the airplane and one compass is parallel to the surface of the airplane's wings. To simplify, we can call the two compasses perpendicular to the surface of the wings of the airplane « the compasses on the bottom » and we can call the compass parallel to the surface of the wings of the airplane « the compass on the top ».

The compasses on the bottom initially have a tilt of 90°C relative to the geometric plane of the sea level, while the compass on the top initially has a tilt of 0°C relative to the geometric plane of the sea level. The continuous supervision of the inclination of the three compasses can be made using inclinometers or other known technologies and techniques.

In addition, it should be noted that if the inclination of a compass relative to the geometric plane of the sea level exceeds 180°C then the needle of this compass instantly turns 180°C which can affect our reading of the angles of rotation of the airplane. In this case, the computerized system responsible for reading the compass must be able to abolish this sudden 180°C change in the compass needle. The other solution to this problem is to attach to the back of each of the three compasses another similar compass oriented in the opposite direction. As soon as the computerized system detects the sudden change of 180°C in a compass, it will then automatically switch to reading the angle of rotation in the compass attached to its back since the difference between these two joined compasses is exactly 180°C.

In this special case of the normal inclination of the airplane parallel to the geometric plane of the sea level, reading the angles of rotation of the airplane on the three compasses is easy and we do not need to make any projections on the geometric plane. However, it should also be noted that the rotation of the compass from above changes and affects the variation of the angles of the other two compasses. In addition, during free fall and loss of control over the airplane, the airplane can turn in any direction and the three axes of the airplane then play the same role in this airplane. In this case, we need the projections of the inclinations of each one of the compasses in relation to the geometric plane of the sea level to succeed in the calculations that allow the reading of the true angles of rotation of the airplane around its three orthogonal axes.

The Case of the Free Fall of the Airplane: The Study of the Angles by Using the Inclinations

In the first presentation of the compass system of this invention, we only explained the principle of rotation of a single axis of the airplane independently of the two other rotations of the other two axes. To resolve this problem, we will then use the thesis entitled: "A thesis about Newtonian mechanics rotations and about differential operators" (Louiz, 2020). We will follow similar steps in order to avoid the change of reference frame presented in this thesis in order to resolve this problem and facilitate the work of the computer programmers responsible for the development of the computerized system of this invention. We will use the following figure.

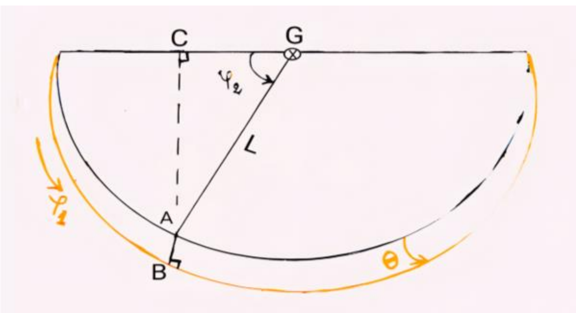

Fig. 3: The only circle of angle φ_2 which is drawn by the rotation of the axis studied in the airplane and which can be projected in the form of the ellipse of angle φ_1 in the corresponding compass

We know that the axis that makes a rotation (a revolution) around itself does not change its position or its orientation in space. We must also specify that the geometric plane of the elliptical rotation φ_1 is parallel to the geometric plane of sea level and that it does not belong to the inclined geometric plane of the rotation disk of the compass needle where we read the angle φ_1 and this is what is explained in the following statements. Also, despite any inclination of the compass of the axis making a rotation (a revolution) around itself, the rotation angle of the disk of the compass needle is the same angle of revolution of the related axis rotating around itself.

We consider in Fig. 3 that (AG) is an airplane axis of rotation that undergoes, without counting its revolution around itself, a rotation in space of angle φ_2 caused by another axis that performs a rotation around itself (revolution) of angle φ_1 which is readable on its corresponding compass. We consider in Fig. 3 that the length of the segment [AG] is L.

In order to study such an effect of a single axis on the other, we know that in space only a single circle of angle φ_2 which is drawn by the rotation of the studied axis can be projected in the form of the ellipse of angle φ_1 knowing that the rotation geometric plane of the axis studied (geometric plane of the rotation φ_2) is inclined in space with an angle θ where $0 < \theta < \frac{\pi}{2}$ and this ellipse with angle φ_1 is considered parallel to the geometric plane of the sea level since the angle φ_1 is the angle readable on the corresponding compass.

The free compass needle tries always to be completely stuck to a line in the Earth's magnetic field parallel to the plane of sea level. This dictates that the natural reaction of the free compass needle to the Earth's magnetic field always occurs parallel to the plane of sea level. Hence, we should specify again that the geometric plane of the elliptical rotation φ_1 is parallel to the geometric plane of the sea level and it does not belong to the inclined geometric plane of the compass disk where we read the angle φ_1.

The circular rotation φ_2 of the studied axis (AG) is inclined and occurs in the geometric plane in black in the upper part of Fig. 3 and the projection of this rotation on the geometric plane of the sea level is the elliptical rotation φ_1 which occurs in the geometric plane in orange in the lower part of Fig. 3. The angle of the elliptical rotation φ_1 is the same angle readable on the compass of the axis in revolution around itself and which causes this rotation of the studied axis. The two geometric planes of rotation of φ_1 and φ_2 intersect in the line which is the support of the segment [GC] in Fig. 3.

The angle of inclination between the two geometric planes of rotation is the angle θ (in orange). The angle θ is therefore an inclination of the geometric plane of rotation of the axis studied (geometric plane of the rotation φ_2) relative to the geometric plane of the sea level. We must then find the relationship between the two angles of rotation φ_1 and φ_2.

Figure 3, point A belongs to the geometric plane of rotation in the upper part of Fig. 3 in black and its orthogonal projection in the geometric plane of rotation in the lower part of Fig. 3 in orange is the point B. The orthogonal projection of the point A on the line of intersection (GC) is the point C.

We can directly calculate the following formulas:

$$AC = L \times \sin(\varphi_2) \quad (1)$$

$$AB = L \times \sin(\varphi_2) \times \sin(\theta) \quad (2)$$

$$GB = L \times \sqrt{1 - \sin(\varphi_2)^2 \times \sin(\theta)^2} \quad (3)$$

We then deduce the equation of the ellipse which makes the rotation φ_1 :

$$\cos(\varphi_1)^2 = \frac{1}{1-\sin(\varphi_2)^2\times\sin(\theta)^2} - \frac{\sin(\varphi_1)^2}{\cos(\theta)^2} \quad (4)$$

with: $0 < \theta < \frac{\pi}{2}$

After a simple triangular calculation, we deduce the easy computer-calculable relationship between the two angles of rotation φ_1 and φ_2 :

$$\sin(\varphi_1)^2 = \frac{\cos(\theta)^2\times\sin(\varphi_2)^2}{1-\sin(\varphi_2)^2\times\sin(\theta)^2} \text{ with : } 0 < \theta < \frac{\pi}{2} \quad (5)$$

Explanations for the Use of Compasses in the Study Despite their Inclinations

On the compass of each axis that makes a rotation (revolution) around itself, we read the angle of this revolution without taking into consideration the inclination of this axis or its related compass except in the case of an inclination of 180 degrees of the compass and that we explained above. We consider that this angle of revolution is φ_1 and around the axis “i”. We know that this revolution considered elliptical affects the two other compasses of the axes “j” and “k” since the revolution of angle φ_1 causes a circular rotation φ_2 to the geometric plane which joins the two axes “j” and “k” and we want to define this angle φ_2. The effect of this resulting circular rotation φ_2 is similar on the two compasses of the two axes “j” and “k”. As calculated above, the relationship between the two angles φ_1 and φ_2 obeys the following formula:

$$\sin(\varphi_1)^2 = \frac{\cos(\theta)^2\times\sin(\varphi_2)^2}{1-\sin(\varphi_2)^2\times\sin(\theta)^2} \text{ with : } 0 < \theta < \frac{\pi}{2}$$

The results of this formula are easily calculated by computer. We give the example of the effect of the axis “i” on the two other axes “j” and “k”:

If the axis “k” is not in simultaneous revolution around itself, we read in the compass of the axis “j” the angle of rotation of the axis “j” around itself (revolution) but added to the angle φ_2 which is caused by the simultaneous rotation (revolution) of the axis “i” around itself. The reading of φ_1 of the axis “i” is done directly on its compass considering that the geometric plane of rotation φ_1 is parallel to the geometric plane of the sea level, then we calculate each angle by the formula (5) demonstrated.

Likewise, if the axis “j” is not in simultaneous revolution around itself, we read in the compass of the axis “k” the angle of rotation of the axis “k” around itself (revolution) but added to the angle φ_2 caused by the simultaneous rotation (revolution) of the axis “i” around itself. The reading of φ_1 of the axis “i” is done directly on its compass considering that the geometric plane of rotation φ_1 is parallel to the geometric plane of the sea level, then we calculate each angle by the formula (5) demonstrated.

Generalized Application

These explanations mean that when we read an angle $\Delta\alpha_1$ on the compass of the axis “i” and we simultaneously read an angle $\Delta\beta 1$ on the compass of the axis “j” and we simultaneously read an angle $\Delta\gamma_1$ on the compass of the axis “k”, we must not forget to calculate the angle $\Delta\alpha_2$ caused by the revolution of the axis “i” around itself and the angle $\Delta\beta_2$ caused by the revolution of the axis “j” around itself and the angle $\Delta\gamma_2$ caused by the revolution of the axis "k" around itself. These calculations allow us to find the angle $\Delta\alpha$ which is the true angle of rotation of the airplane around the axis "i" and to simultaneously find the angle $\Delta\beta$ which is the true angle of rotation of the airplane around the axis “j” and simultaneously find the angle $\Delta\gamma$ which is the true angle of rotation of the airplane around the axis “k”. We then have this system of simultaneous relationships:

$$\Delta\alpha_1 = \Delta\alpha + \Delta\beta_2 + \Delta\gamma_2 \text{ and } \Delta\beta_1 = \Delta\beta + \Delta\alpha_2 + \Delta\gamma_2 \quad (6)$$
$$\text{and } \Delta\gamma_1 = \Delta\gamma + \Delta\beta_2 + \Delta\alpha_2$$

This is true because when we study the rotation of the intersection line of the compass disk with the geometric plane of rotation of its related perpendicular axis “j” which is inclined in space with a constant angle θ, we notice that this intersection line makes the same rotation $\Delta\alpha_2$ of the two axes “j” and “k” which is caused by the revolution of the axis “i”. Hence, all the disk of rotation of the compass needle which is perpendicular to the axis “j” makes the rotation $\Delta\alpha_2$. We can also add that with the same inclination angle θ, the disk of this compass will perform an angle of rotation of 360°C when the axes “j” and “k” perform an angle of rotation of 360°C which is caused by the complete revolution of the axis “i” around itself.

And thus:

$$\Delta\alpha = \Delta\alpha_1 - \Delta\beta_2 - \Delta\gamma_2 \text{ and } \Delta\beta = \Delta\beta_1 - \Delta\alpha_2 - \Delta\gamma_2 \quad (7)$$
$$\text{and } \Delta\gamma = \Delta\gamma_1 - \Delta\beta_2 - \Delta\alpha_2$$

We have also:

$$\sin(\Delta\alpha_1)^2 = \frac{\cos(\theta_1)^2\times\sin(\Delta\alpha_2)^2}{1-\sin(\Delta\alpha_2)^2\times\sin(\theta_1)^2} \text{ with } 0 < \theta_1 < \frac{\pi}{2} \quad (8)$$
$$\text{and } \theta_1 = \left|\frac{\pi}{2} - |\theta_i|\right|$$

DOI: 10.3844/jastsp.2024.4.13

where θ_i is the angle of inclination of the axis "i" relative to the geometric plane of the sea level which is calculated by the corresponding inclinometer.

We get consequently:

$$\sin(\Delta\alpha_2)^2 = \frac{\sin(\Delta\alpha_1)^2}{\cos(\theta_1)^2+\sin(\Delta\alpha_1)^2\times\sin(\theta_1)^2} \text{ with:} \quad (9)$$
$0 < \theta_1 < \frac{\pi}{2}$ and $\theta_1 = |\frac{\pi}{2} - |\theta_i||$

And thus we get:

$$\Delta\alpha_2 = \arcsin(\frac{\sin(\Delta\alpha_1)}{\sqrt{\cos(\theta_1)^2+\sin(\Delta\alpha_1)^2\times\sin(\theta_1)^2}}) \text{ with:} \quad (10)$$
$0 < \theta_1 < \frac{\pi}{2}$ and $\theta_1 = |\frac{\pi}{2} - |\theta_i||$

where θ_i is the angle of inclination of the axis "i" relative to the geometric plane of the sea level which is calculated by the corresponding inclinometer.

We will have $\Delta\alpha_2 > \frac{\pi}{2}$ if and only if $\Delta\alpha_1 > \frac{\pi}{2}$ with $\Delta\alpha_1$ directly readable on the compass.

By following the same steps, we can calculate:

$$\Delta\beta_2 = \arcsin(\frac{\sin(\Delta\beta_1)}{\sqrt{\cos(\theta_2)^2+\sin(\Delta\beta_1)^2\times\sin(\theta_2)^2}}) \text{ with:} \quad (11)$$
$0 < \theta_2 < \frac{\pi}{2}$ and $\theta_2 = |\frac{\pi}{2} - |\theta_j||$

where θ_j is the angle of inclination of the axis "j" relative to the geometric plane of the sea level which is calculated by the corresponding inclinometer.

We will have $\Delta\beta_2 > \frac{\pi}{2}$ if and only if $\Delta\beta_1 > \frac{\pi}{2}$ with $\Delta\alpha_1$ directly readable on the compass.

We can also calculate:

$$\Delta\gamma_2 = \arcsin(\frac{\sin(\Delta\gamma_1)}{\sqrt{\cos(\theta_3)^2+\sin(\Delta\gamma_1)^2\times\sin(\theta_3)^2}}) \text{ with:} \quad (12)$$
$0 < \theta_3 < \frac{\pi}{2}$ and $\theta_3 = |\frac{\pi}{2} - |\theta_k||$

where θ_k is the angle of inclination of the axis "k" relative to the geometric plane of the sea level which is calculated by the corresponding inclinometer.

We will have $\Delta\gamma_2 > \frac{\pi}{2}$ if and only if $\Delta\gamma_1 > \frac{\pi}{2}$ with $\Delta\gamma_1$ directly readable on the compass.

The variations in the compass angles expressed in Formulas (6-7) can then easily be calculated by computer.

Remarks

Experimentally and thanks to the projection of the compass disk, we get:

If we have $\theta_i = \frac{\pi}{2}$ then $\Delta\alpha_1 = \Delta\alpha_2$ (13)

If we have $\theta_j = \frac{\pi}{2}$ then $\Delta\beta_1 = \Delta\beta_2$ (14)

If we have $\theta_k = \frac{\pi}{2}$ then $\Delta\gamma_1 = \Delta\gamma_2$ (15)

These three remarks can also be used when the inclination is close to $\frac{\pi}{2}$.

We should also pay attention to the inclination of the compass when it exceeds 180°C as explained.

We can also get experimentally and thanks to the projection of the compass disk these formulas:

If we have $\theta_i = 0$ then $\Delta\alpha_2 = 0$ (16)

If we have $\theta_j = 0$ then $\Delta\beta_2 = 0$ (17)

If we have $\theta_k = 0$ then $\Delta\gamma_2 = 0$ (18)

These three remarks can also be used when the inclination is close to 0.

We should also pay attention to the inclination of the compass when it exceeds 180°C as explained.

We should also know that when the rotations of the airplane concerned by this invention are possible only around the axis “i”, then the angles β and γ are constants and we consider in our calculations that: $\Delta\beta = \Delta\gamma = 0$.

When the rotations of the airplane concerned by this invention are possible only around the axis “i” and “j”, then the angle γ is a constant and we consider in our calculations that: $\Delta\gamma = 0$.

Materials and Methods

The methods used in this article are based on very known principles of the compass and of the Earth electromagnetic field and also on the previously published thesis about Newtonian mechanics rotations (Louiz, 2020) which has the purpose to study objects rotations without using the known method of change of reference frames. The change of reference frames is a mathematically correct method. However, we know that this method can't be used in some fields of mechanics where the velocity of rotation is high and the precision is needed like in the field of quantum mechanics where this method leads to contradictions. Hence, avoiding the change of reference frame is the rule in this article which makes the findings of this work accurate and mathematically easier to achieve.

The observations behind this article have been made by using a classical compass. However, any digital compass or electronic compass based on the electromagnetic field of the Earth can also be used as a tool for this invention by adapting the work and the orientation of that compass with the work and orientation of the classical compass according to the principles stated and described in the inventions of this article. Also, since the formulas of the modelling of this article inventions are very simple, we can use common simple programmable calculators to process these formulas as a part of the informatic or digital system of this invention instead of an expensive computer. And thus, this invention can be adapted to any size needed for its use in all industrial fields.

Results and Discussion

Most of the works proposed for the study of objects rotations use external reference frames or external sensing procedures similar to the propositions of a known expired invention of the inventor Reister Russell patented in the USA in 1969 (Reister, 1969). However, the invention of this article avoids external sensing methods or external reference frames that make the study of rotating objects very complicated. For example, the external reference frame and at least a part of the external sensing system used for the study of aircrafts rotations should be fixed on a satellite or in a station on Earth which means that we also need in this case a complicated network for the transfer of data between all the parts of the external sensing system and this makes these kinds of systems complicated and usually useless for a reaction in the case of an emergency or accident of the concerned aircraft.

External sensing and external reference frames are not needed in the inventions of this article about rotating objects (Louiz, 2023b) and this is the fact that makes this applied invention about rotating objects more effective as a solution in case of an emergency or accident of the concerned aircraft or any similar transport vessel. The methods proposed in this article can also be very useful for the design of a new more independent autopilot for aircrafts and similar transport vessels.

Some other works which try to study rotating objects use principles of the gravitation of Earth through gyroscopes methods. However, any gyroscope is known to be unable to study fast moving objects moving on trajectory from the east to the west since gyroscopes are always dependent on the rotation of Earth. Unlike the compass, a gyroscope is also subjected to relative azimuth and it can't measure linear motion in any direction, or any static angle of orientation.

A previous South Korean invention (Lim *et al*., 2013) patented in 2013 uses principles of the electromagnetic field of Earth and ideas similar to the ones presented in this article. However, the South Korean invention uses only one inclinometer even if it is unable to define exactly the orientations of the axes of the used reference frame for all cases of rotations. Also, the mathematical models of the South Korean invention are based on matrices in order to find solutions. However, the efficiency of these pure mathematics methods of kinematic rotations especially with high linear speed of rotation has been criticized in the beginning of a thesis about the use of pure mathematics with Newtonian mechanics in Astronomy (satellites) and quantum mechanics (Louiz, 2020). Furthermore, the mathematical tools used in this article as a modelling of the inventions are very simple compared to the other research articles which apply methods based on the change of references and may apply other tools of pure mathematics and matrices (Hall and Sands, 2023).

And thus, the specialists in all the industrial fields of application who need an independent study of rotating objects without any external sensing or external reference frames will prove the usefulness and the real abilities and accuracy of the methods and formulas of this article inventions despite the potential high velocities of their studied objects.

Conclusion

This article presented a summarized description of the invention patent accepted in OMPIC in Morocco and titled: “Un système d’urgence en cas d’accident ou de défaillance dans un avion pour permettre le sauvetage”. This invention is an emergency system that uses thrusters for the translation and the rotation of the airplane which is broken down or damaged in order to restore balance in the air to this airplane. Hence this invention allows safe and reliable deployment of the emergency aerostat or any other rescue solutions. This thruster system should process computer data from a control system that uses a newly proposed method of navigation based on the principles of the ordinary compass. This invention can therefore bring the airplane back into balance and even help it navigate with the aerostat and this allows the rescue of travelers, pilots and cargo.

The new proposed system of navigation is based on the principle of compasses and can be applied in the navigation of aircraft or submarines. However, the explanations provided in this article are based on an application in the case of airplanes by using an orthonormal reference frame of three axes "i", "j" and "k" which are fixed on the airplane. Using this principle of compasses requires that each one of the three axes must pass exactly through the center of its corresponding compass and it must be exactly perpendicular to this compass disk in order to have the best precision.

When we read an angle $\Delta\alpha_1$ on the compass of the axis “i” and we simultaneously read an angle $\Delta\beta_1$ on the compass of the axis “j” and we simultaneously read an angle $\Delta\gamma_1$ on the compass of the axis “k”, we must not forget to calculate the angle $\Delta\alpha_2$ caused by the revolution of the axis “i” around itself and the angle $\Delta\beta_2$ caused by the revolution of the axis “j” around itself and the angle $\Delta\gamma_2$ caused by the revolution of the axis “k” around itself. We deduce consequently the angle $\Delta\alpha$ which is the true angle of rotation of the airplane around the axis “i” and the angle $\Delta\beta$ which is the true angle of rotation of the airplane around the axis “j” and the angle $\Delta\gamma$ which is the true angle of rotation of the airplane around the axis “k”. Thus, we should use this system of simultaneous relationships:

We have:

$$\Delta\alpha_2 = \arcsin\left(\frac{\sin(\Delta\alpha_1)}{\sqrt{\cos(\theta_1)^2+\sin(\Delta\alpha_1)^2\times\sin(\theta_1)^2}}\right) \text{ with:}$$

$$0 < \theta_1 < \frac{\pi}{2} \text{ and } \theta_1 = |\frac{\pi}{2} - |\theta_i||$$

and:

$$\Delta\beta_2 = \arcsin\left(\frac{\sin(\Delta\beta_1)}{\sqrt{\cos(\theta_2)^2 + \sin(\Delta\beta_1)^2 \times \sin(\theta_2)^2}}\right) \text{ with:}$$
$$0 < \theta_2 < \frac{\pi}{2} \text{ and } \theta_2 = |\frac{\pi}{2} - |\theta_j||$$

and:

$$\Delta\gamma_2 = \arcsin\left(\frac{\sin(\Delta\gamma_1)}{\sqrt{\cos(\theta_3)^2 + \sin(\Delta\gamma_1)^2 \times \sin(\theta_3)^2}}\right) \text{ with:}$$
$$0 < \theta_3 < \frac{\pi}{2} \text{ and } \theta_3 = |\frac{\pi}{2} - |\theta_k||$$

And also:

$$\Delta\alpha = \Delta\alpha_1 - \Delta\beta_2 - \Delta\gamma_2 \text{ and } \Delta\beta = \Delta\beta_1 - \Delta\alpha_2 - \Delta\gamma_2$$
$$\text{and } \Delta\gamma = \Delta\gamma_1 - \Delta\beta_2 - \Delta\alpha_2$$

The variation of the angles $\Delta\alpha$, $\Delta\beta$ et $\Delta\gamma$ as a function of time allows us to know the moment of loss of control of the airplane and to know the thrusters and the power required to restore balance to the airplane.

The calculation of the angles $\Delta\alpha$, $\Delta\beta$ et $\Delta\gamma$ of the rotations of the airplane around its three orthogonal axes defined in this article is continuous thanks to the computer of the computerized system of this invention.

We could also make the following remarks:

$$\text{If we have } \theta_i = \frac{\pi}{2} \text{ then } \Delta\alpha_1 = \Delta\alpha_2$$

$$\text{If we have } \theta_j = \frac{\pi}{2} \text{ then } \Delta\beta_1 = \Delta\beta_2$$

$$\text{If we have } \theta_k = \frac{\pi}{2} \text{ then } \Delta\gamma_1 = \Delta\gamma_2$$

$$\text{If we have } \theta_i = 0 \text{ then } \Delta\alpha_2 = 0$$

$$\text{If we have } \theta_j = 0 \text{ then } \Delta\beta_2 = 0$$

$$\text{If we have } \theta_k = 0 \text{ then } \Delta\gamma_2 = 0$$

where, θ_i and θ_j, and θ_k are the angles of inclination of the axes "i", "j" and "k" relative to the geometric plane of the sea level and which are calculated by the corresponding inclinometers.

This part of the article that explains the newly proposed compass navigation system by using the example of airplane navigation will be therefore of service to the programmers of the computerized system of this invention since this will allow programmers to create the computer program of this invention easily with the minimum possible computer code and this will also allow the installation of an ordinary cheaper calculation computer for the computerized system of this presented invention. Furthermore, the navigation system of this article, compared to other declared benchmarks, can make airplanes achieve navigation more independent from terrestrial control stations and satellites and can significantly enhance future autopilot systems.

NB: These explained principles and formulas can be very useful for the simulation of all moving objects such as aircraft and submarines.

Acknowledgment

Thank you to the publisher for their support in the publication of this research article. We are grateful for the resources and platform provided by the publisher, which have enabled us to share our findings with a wider audience. We appreciate the effort

Funding Information

The authors have not received any financial support or funding to report.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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